Evaluating the Impact of Terrain Characteristics on Biomass Patterns in Liberia

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Abstract

The distribution of biomass is essential for effective stewardship of natural resources. This research focuses on Liberia, which has diverse landscapes that require a nuanced examination of how terrain features affect biomass patterns. Using Geographic Information System (GIS) technology, the study utilizes data sources such as the Liberia Biomass Shapefile and Digital Elevation Model. Thematic maps, statistical tests, and spatial overlays uncover complex relationships. The results indicate significant variations in biomass, highlighting areas with high potential for sustainable resource management. The connection between topography and biomass production has implications for climate change strategies and biodiversity protection. Despite limitations, this research provides valuable insights for evidence-based decision-making in ecosystem management in Liberia.

Keywords: Biomass patterns, Terrain characteristics, Geographic Information System (GIS), Liberia, Climate change mitigation, Biodiversity conservation, Sustainable resource stewardship, Spatial analysis, Topography, Geospatial analysis, Digital Elevation Model (DEM), and Environmental protection.

1 Introduction

The distribution of biomass is critical for understanding and managing natural systems. Evaluating how terrain attributes influence these patterns is vital for informed decision-making (Lechner et al., 2018). In Liberia, a country with varied landscapes, such analysis is important for environmental protection and sustainable use of resources. Geographic Information System (GIS) technology offers a robust framework for spatial analyses, making it an essential tool for this research (Bivand et al., 2013). Liberia's distinct terrain features, spanning coastal plains to mountain ranges, make a dynamic setting where biomass patterns are shaped by topography, soils, and climate. This study aims to assess how terrain characteristics impact biomass patterns in Liberia, utilizing GIS to enable a thorough spatial analysis.

2 Literature Review

Geospatial analysis has become an increasingly common tool in biomass research, enabling scientists to investigate the complex interrelationships between topographical features and the distribution of biomass (Mitchard et al., 2013). Prior studies have shown the importance of incorporating topographic data, such as Digital Elevation Models (DEMs), to understand biomass patterns (Baccini et al., 2012). The use of GIS technology facilitates the mapping and visualization of biomass data across different terrain characteristics, providing valuable insights (Foody et al., 2019). The literature emphasizes considering topographical variables like elevation, slope, and aspect in biomass studies (Baccini et al., 2012; Mitchard et al., 2013). Features of the terrain influence factors including drainage, soil moisture, and sunlight exposure, all of which lead to variations in biomass across different land areas (Lechner et al., 2018). However, current research has a gap regarding the specific context of Liberia. While existing studies have examined the terrain's impact on biomass globally, Liberia's unique environmental conditions and diverse topography require focused analysis. This research aims to contribute to current knowledge by thoroughly evaluating how Liberia's terrain attributes influence its biomass patterns.

3 Methodology

The geographical scope of this study is the country of Liberia, with its diverse landscapes and ecosystems. The research encompasses the whole nation, utilizing GIS technology to include spatial data about terrain features and biomass distributions. Data sources are a Liberia Biomass Shapefile showing biomass averages across regions from 1999-2023 (Clark et al.,2011; Garcia et al., 20), plus a Digital Elevation Model (DEM) for Liberia with terrain information like elevation, slope, and aspect (Y Wang, et al 2021). QGIS, a commonly used GIS program (Conag, et al 2019), will be employed for geospatial analysis. The Biomass Shapefile will generate thematic maps of biomass patterns. The DEM will derive terrain variables. Spatial overlays and statistical tests will examine relationships between terrain and biomass. DEM-derived terrain layers for elevation, slope, and aspect will be created. These will be integrated with the Biomass Shapefile to analyze correlations and patterns. Temporal analysis will investigate how biomass patterns have changed over time (1999-2023). Trends will be reviewed along with terrain factors to identify potential shifts or correlations. Limitations include possible data inaccuracies and the assumption that terrain characteristics alone drive biomass variations (Klop et al.2008).

4 Results

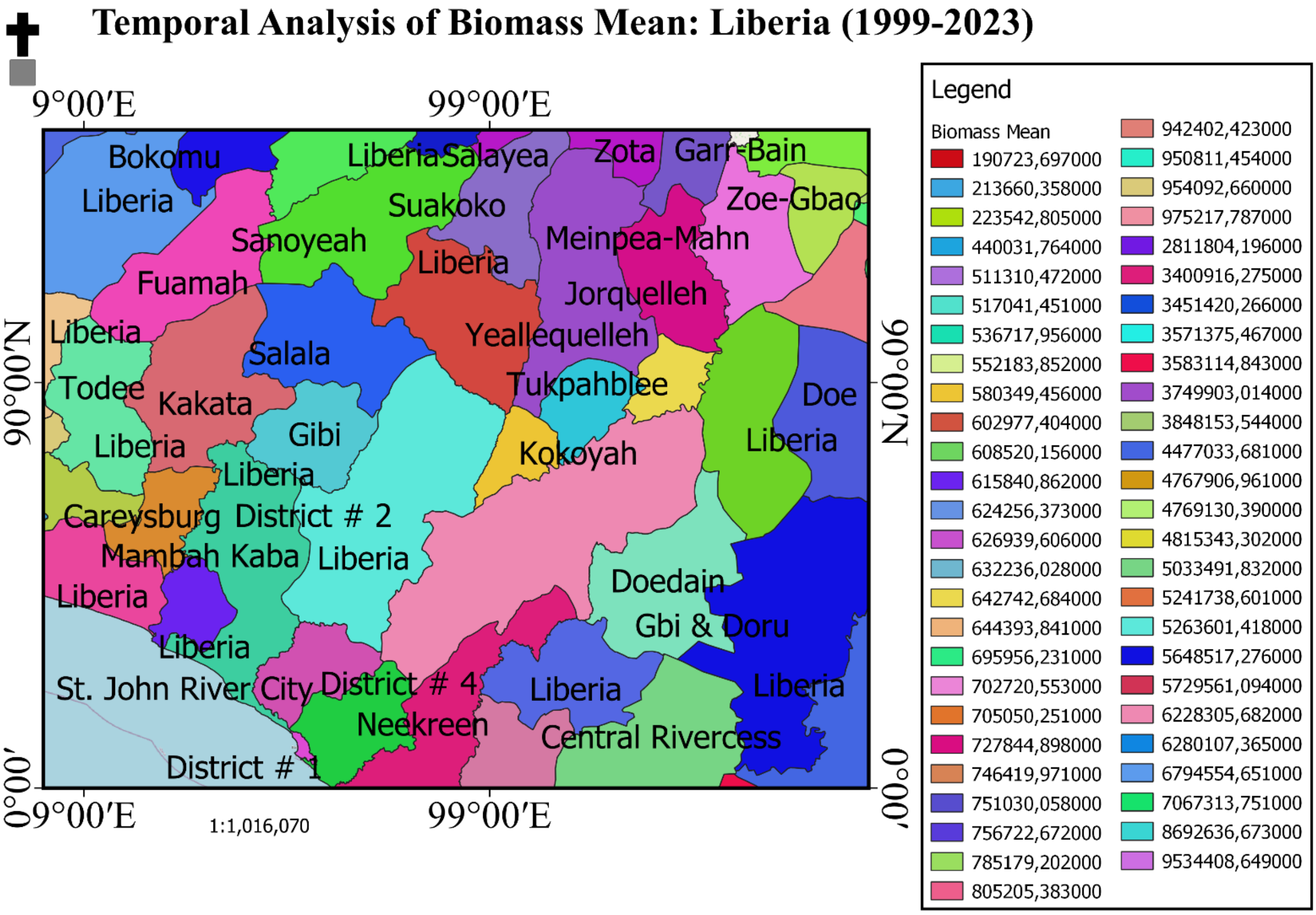
Temporal Analysis of Biomass Mean: Liberia (1999-2023)

Figure 1. Shows the Biomass mean productions of Liberia from 1999 to 2023.

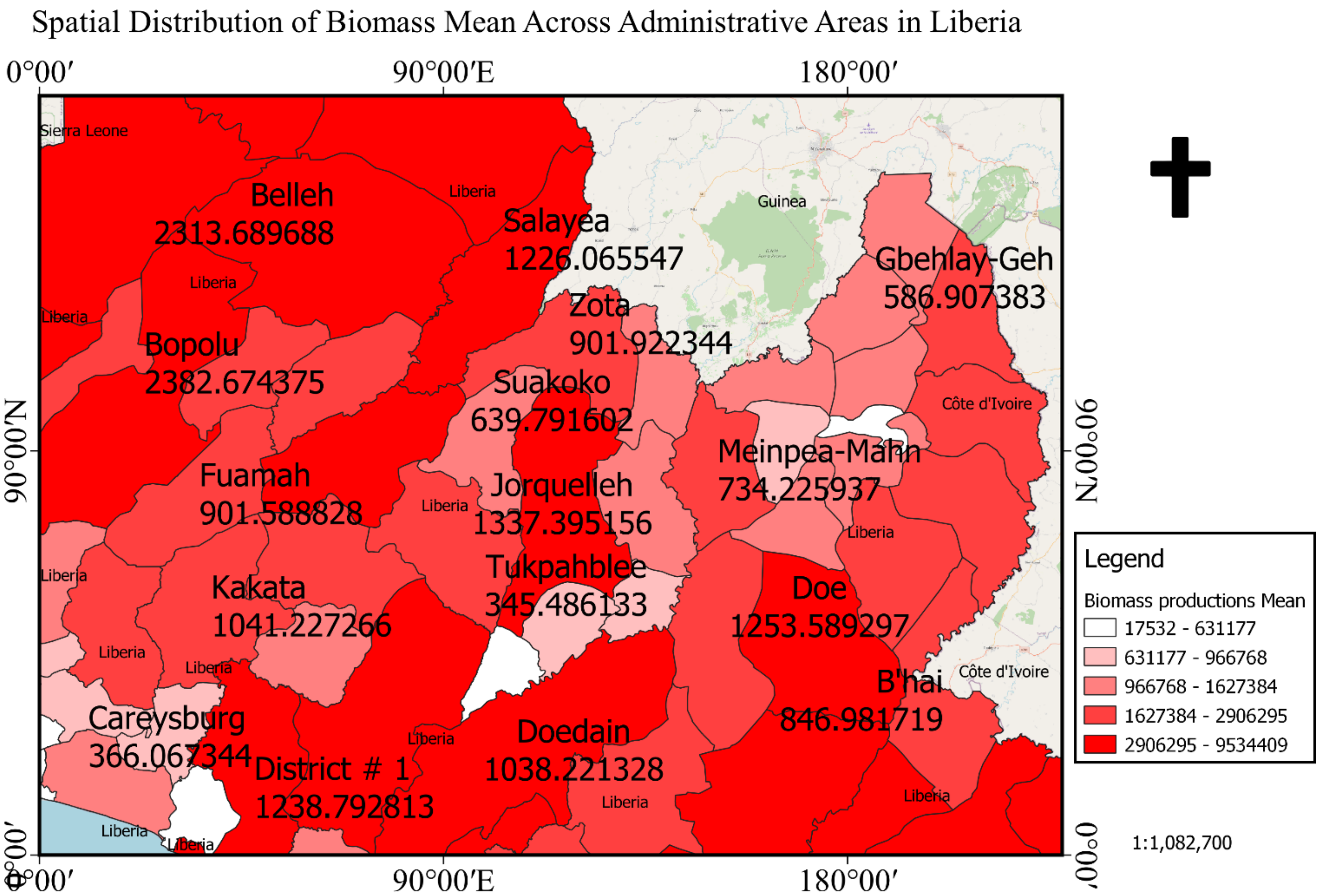

Figure 2. Shows the Biomass mean across the administrative areas of Liberia.

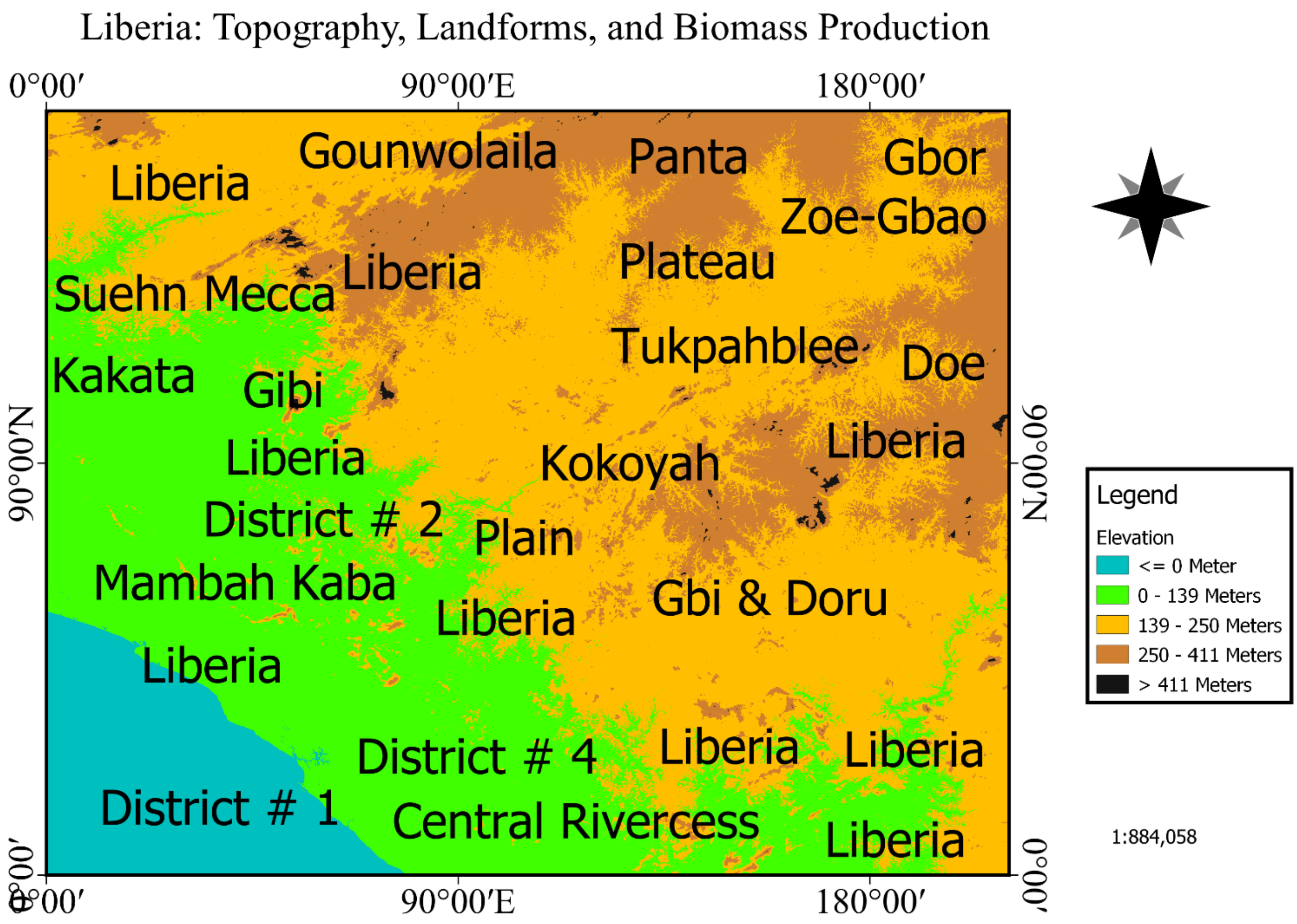

Figure 3. Shows the topography distribution of Biomass production across Landforms in Liberia

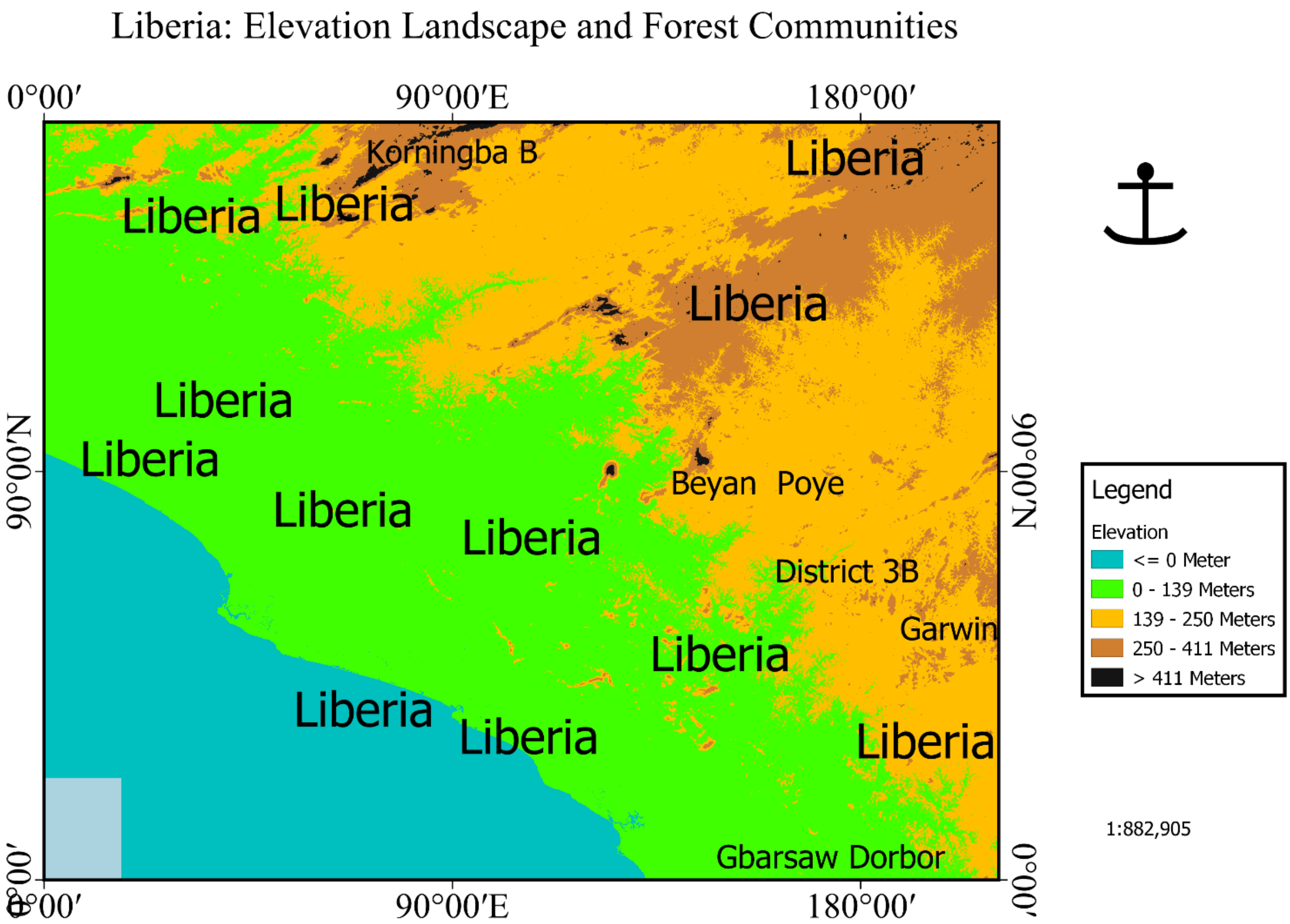

Figure 4. Shows the y distribution of forest communities across the Elevation landscape.

5 Discussion

5.1 Biomass Mean Production and Geographic Distribution

Figure 1 gives a comprehensive overview of Liberia's average biomass production from 1999 to 2023. It shows that the highest average biomass production is over nine million. Areas with notably high average biomass production include Fuamah, Minpea Mahn, Yeallewquelleh, and others. This aligns with expectations since these regions often have favorable ecological conditions for biomass production (Adedoyin et al., 2020). The identification of certain areas, like Salala, Kokoyah, and Central Rivercess, highlights the spatial differences in biomass production, likely influenced by various ecological and climatic factors. Figure 2 further analyzes the biomass averages, indicating a range from 2,906,295 to 9,534,409 across different regions. Areas such as Doe, Doedain, and Bopolu stand out with high biomass averages, pointing to rich biomass production potential. In contrast, regions like Kakata, Gbehlay-Geh, and Careysburg show medium to low biomass averages. This detailed analysis guides policymakers and environmental scientists in pinpointing areas with the greatest biomass potential for sustainable resource management and conservation (Mbow et al., 2014).

5.2 Topography and Biomass Productions

The topography of Liberia includes plains, plateaus, and mountains, as depicted in Figure 3, which shows the maximum elevation across the country. The highest points are the mountainous areas, which reach up to 411 meters. These include the Gbi & Doru, Panta, and Doe mountains. Elevations between 250 to 411 meters are found in regions like Kokoyah, Gbor, and Goundwolaila. Notably, the areas with elevations ranging from 0 to 139 meters, where much of the biomass production occurs, include places such as Mambah Kaba, Kakata, and Central Rivercess. There is a clear link between topography and biomass production. Mountain environments often contain distinct ecological niches that affect the types of vegetation and, in turn, biomass production (Brown et al., 1994). Understanding the topographical differences provides insight into the ecological factors that shape biomass distribution. This knowledge is vital for sustainable land use planning, reforestation efforts, and climate change mitigation initiatives (SRTM,2015).

5.3 Forest Communities and Elevation

The information in Figure 4 explores specific forest communities and illuminates their elevation ranges. The Beyan Poye community, found in areas with elevations ranging from 0 to 139 meters, demonstrates the ability of certain communities to adapt to lower elevations. In contrast, the Gbarsaw Dorbor community flourishes in regions up to 139 meters in elevation, indicating the diverse ecological niches that support different forest communities. The categorization of forest communities based on elevation corresponds with ecological principles, where vegetation types and species makeup are influenced by altitude (Körner, 2007). Understanding the elevation preferences of forest communities aids focused conservation efforts, enabling the protection of biodiversity across varying elevations.

6 Conclusion

The spatial examination of biomass productivity, topography, and forest composition presented in Figures 1 to 4 reveals the complex interrelationships between these factors across Liberia. The results offer important insights for policymakers, environmental researchers, and conservationists seeking to optimize land use, encourage sustainable resource stewardship, and protect biodiversity.

6.1 Ramifications for Sustainable Resource Stewardship

Pinpointing regions of high biomass productivity, such as Fuamah, highlights prospects for sustainable resource stewardship and bioenergy generation (Zhang et al., 2018). Policymakers can leverage this data to formulate approaches for promoting accountable land use, reforestation efforts, and the growth of biomass-dependent industries.

6.2 Climate Change Mitigation and Adaptation

The link between topography and biomass production has implications for strategies to address and adapt to climate change (Keith et al., 2017). Mountain regions, with their distinctive ecosystems, play a vital role in absorbing carbon and sustaining biodiversity. Identifying these areas as key carbon sinks informs efforts to mitigate climate change and underscores the necessity of safeguarding these landscapes.

6.3 Protecting Biodiversity and Ecosystem Services

Categorizing forest communities based on elevation contributes to biodiversity protection efforts. Understanding the elevation preferences of different species guides conservationists in prioritizing areas for safeguarding and restoration. Protecting biodiversity is not only essential for maintaining ecosystem services but also for ensuring the resilience of ecosystems to environmental shifts (Díaz et al., 2019).

6.4 Limitations and Future Research Directions

It is important to point out the shortcomings of this study, namely the dependence on satellite imagery and the lack of verification in the field. Further research could incorporate ground surveys, evaluations at the species level, and long-term tracking to improve the precision of biomass estimates and forest community characterizations. In summary, this geographical analysis provides valuable insights into the sustainable stewardship of Liberia's ecosystems. The spatial breakdown of biomass output, together with topographical factors and forest community traits, establishes a basis for evidence-guided decision-making. As Liberia navigates the difficulties of environmental sustainability, these understandings can direct policies that balance resource use with conservation, ensuring a harmonious coexistence between human activities and the natural world (Giri C et al 2011).

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